Active Core Concept

Aero engines are operated in very different operating conditions during their flight mission. As an actively controlled core can be adapted to each operating condition, significant operating advantages can be achieved and additional degrees of freedom are offered in the design phase as the core does not have to be designed for the worst case operating point. In NEWAC the two most promising areas for active systems in a core engine will be investigated (Fig. 1).

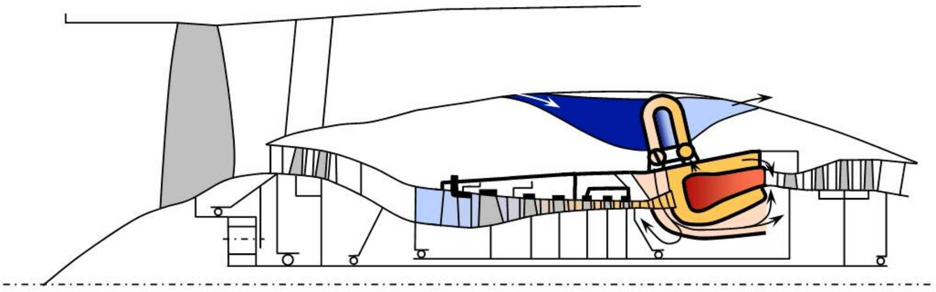

Fig. 1: Schematic of engine with active core elements

The first one is an active cooling system which offers an enormous improvement potential. It lowers the temperature of the cooling air for the HPT and for other cooled parts. In modern core engines a fixed amount of 20% to 30% of the air delivered by the HPC is used for cooling the HPT, thus “bypassing” the cycle and having further detrimental effects on the core.

Cooling air cooling has been identified in /5/ and /6/ for enabling high pressure cycles with high turbine exit temperatures. Nevertheless, the potential for medium OPR cycles is significant as well, as the needed amount of cooling air can be reduced. In the known studies, cooled cooling air is provided only to the turbine blades, and the amount and temperature of the cooled air is fixed. These systems promise only a moderate SFC reduction. In NEWAC a new, highly advanced cooling air system will be investigated for which, not only the rotor blades, but also the stator vanes, the rotor disk and the liners are supplied with cooled cooling air. In addition, the cooling air temperature is actively controlled depending on the mission point. This will reduce the necessary amount of cooling air to a minimum.

Furthermore, as another positive implication of the availability of cooled compressor air, the use of cooled air for cooling the HPC rear cone will be investigated. This component is critical concerning temperature levels and related material stresses and opens up new manufacturing options.

The second area of research within the Active Core are active systems in the HPC itself. The technologies addressed in NEWAC are an active clearance control system (ACC) and an active surge control system (ASC) (Fig. 2).

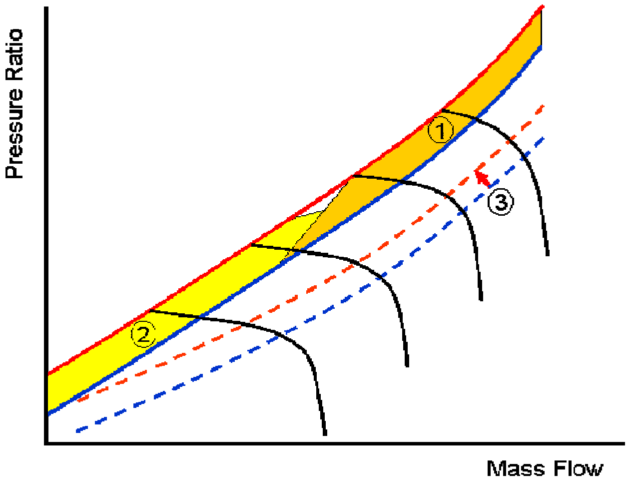

Fig. 2: Compressor map showing surge margin gain of ACC (1) and ASC (2) and the resulting benefit of lifting the operating line (3)

These two technologies should be validated in a core engine test allowing for realistic transient operation, vibrations and temperature levels.

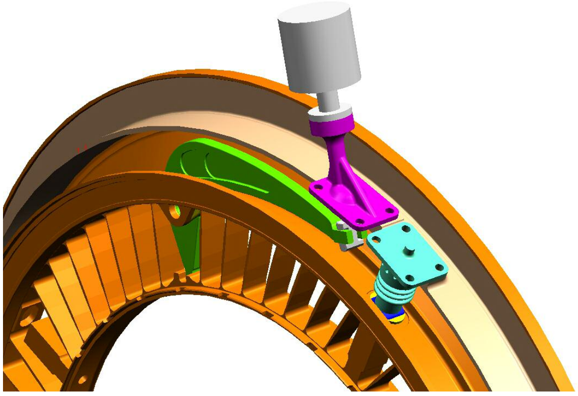

Fig. 3: Example for an active clearance control system

Casing integrated ACC for compressor rear stages provides significantly better efficiency and increased full speed surge margin. Deterioration of radial clearances can be eliminated, thus providing additional efficiency and surge margin for engines in service. Within NEWAC, two types of ACC – a thermal and a very ambitious mechanical approach – will be studied and compared with alternative technologies for tip clearance improvement (Fig. 3).

In addition to active clearance control, active surge control (ASC) for compressor front stages via air injection enhances the operability of the engine at part speed conditions. Together with a rear stage ACC, an optimum operation can be achieved over the full flight envelope as shown in Fig. . The technology enables a design for normal flight operation by eliminating the worst case requirements in part power con-

ditions. Currently no ASC systems are in aircraft use. However, several demonstrators and research compressors exist, which show the system's potential.
In NEWAC, the benefits of ACC and ASC will be investigated and compared with the passive alternative, a multi stage casing treatment. To achieve this target, highly advanced casing treatments will be developed and rig tested to provide a benchmark for the effectiveness of these active systems.

The chosen combination of active and/or passive technologies will then be tested in a core engine at realistic conditions. The key issues for all these systems - flight safety, weight, system complexity and cost – can then be properly evaluated. The objective is to validate a 4 % SFC increase and 1 % propulsion system weight reduction.